eſtabliſhing the *Longitudes* over all the Earth. For, beſides that theſe Eclipſes are very frequent, the Emerſion and Immerſion of theſe *Satellites*, eſpecially in the ſhadow of *Jupiter*, is ſo momentany and ſo ſenſible, that they may be obſerved with the greateſt exactneſs, being altogether exempt from thoſe eſſential inconveniencies that accompany the Eclipſes of the Sun and Moon, which alſo are rare, and whoſe beginning and end are alwaies doubtful by reaſon of a certain ambiguous light.

The Longitudes of places at Sea, Capes, Promontories, and divers Iſlands being once exactly known by this means, would doubtleſs be of great help and conſiderable uſefulneſs to Navigation.

Since Monſieur *Borelli* hath found this way of working Glaſſes, he entruſted the ſecret of it to a perſon of the Academy above-mentioned; and he purpoſeth to publiſh the ſame hereafter, with ſome other conſiderable Obſervations touching the ſame Glaſſes.

A Letter from Liege *concerning Mr.* Newton's *Experiment of the coloured* Spectrum; *together with ſome Exceptions againſt his Theory of* Light *and* Colours.

Honrd Sir,

MR *Gaſcoigne* having received your obliging Letter of *Jan.* 18, with freſh directions from Mr. *Newton*; but wanting convenience to make the Experiment according to the ſaid inſtructions, he has requeſted me to ſupply his want. In compliance with his requeſt I have made many Trials; the iſſue whereof I here acquaint you with: next, with ſome exceptions, grounded on Experiments, againſt Mr. *Newton*'s new Theory of *Light* and *Colours*.

The vertical angle of my Priſm was 60 *deg*; the diſtance of the Wall, whereon the coloured *Spectrum* appeared, from the Window, about 18 foot: The diameter of the Hole in the Window-ſhuts in length the line *a*, which upon occaſions I contracted to half the ſaid diameter; but ſtill with equal ſucceſs as to the main of the Experiment. The refractions on both ſides the Priſm, were as near as I could make them, equal,

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equal,and conſequently about 48 *deg.*40′, the refractive power of Glaſs being computed according to the *Ratio* of the *Sines* 2 to 3. The diſtance of the Priſm from the hole in the Shuts was about 2 inches: The Room darkned to that degree as to equal the darkeſt night, while the hole in the Shuts was covered.

Now as to the iſſue of my Trials; I conſtantly found the length of the coloured image (tranſverſe to the axis of the Priſm) conſiderably greater than its breadth, as often as the Experiment was made on a clear day; but if a bright Cloud were near the Sun, I found it ſometimes exactly as Mr. *Line* wrote you, namely broader than long, eſpecially while the Priſm was placed at a great diſtance from the hole. Which Experiment will not, I conceive, be queſtioned by Mr. *Newton*, it being ſo agreeable to the received laws of Refractions. And indeed the Obſervations of theſe two Learned perſons, as to this particular, are eaſily reconcileable to each other, and both to truth; Mr *Newton* (as appears by his Letter of *Nov.* laſt, wherein more fully he delivers his mind) contending only for the length of the Image (tranſverſe to the axis of the Priſm) in a very clear day; whereas Mr. *Line* only maintain'd the exceſs of breadth, parallel to the ſame axis, while the Sun is in a bright cloud. Though as to what is further delivered by Mr. *Newton* (*Phil. Tranſact. N.* 80. *p.* 3077; and oppoſed by Mr. *Line*, *N.* 129. *p* 501.) namely that the length of the coloured Image was five times the diameter of its breadth; I never yet have found the exceſs above thrice the diameter, or at moſt 3½, while the refractions on both ſides the Priſm were equal. So much as to the matter of fact.

Now as to Mr. *Newton*'s Theory of *Light* and *Colours*, I confeſs, his neat Sett of very ingenious and natural inferences, was to me upon the firſt peruſal a ſtrong conjecture in favour of his new doctrine; I having formerly obſerv'd the like chain of Inferences upon ſearch into Natural truths. But ſince ſeveral experiments of Refractions remain ſtill untouch'd by him, I conceived, a further ſearch into them would be very proper in order to a further diſcovery of the truth of his Aſſertion. For, accordingly as they are found either agreeing with, or diſagreeing from, his new Theory, they muſt needs much ſtrengthen,or wholly overthrow the ſame. The Experiments I pitched upon for this purpoſe, are as follow:

1. Having frequently obſerved , that the form of Objects viewed in the Microſcope (or rather of the Microſcope it ſelf) conſiſts almoſt in an indiviſible point, I concluded , two very ſmall pieces of Silk, the one ſcarlet, the other violet colour, placed near together, ſhould, according to Mr. *Newton*'s Theory, appear in the Microſcope in a very different degree of clarity, in regard their unequal refrangibility muſt cauſe the ſcarlet rays or ſpecies to over-reach the *Retina*, while placed in the due focus of the violet ones, and conſequently muſt occaſion a ſenſible confuſion in the viſion of the former, one and the ſame point of the Scarlet object affecting ſeveral nerves in the *Retina*. Yet upon frequent trials I have not been able to perceive any inequality in this point.

2. The ſecond Experiment I made in Water. I took a braſs Ruler, and faſtening thereunto ſeveral pieces of Silk, red, yellow, green, blew and violet, I placed it at the bottom of a ſquare veſſel of Water: then I retired from the Veſſel ſo far as not to be able to ſee the aforeſaid Ruler and coloured Silks otherwiſe than by help of the refracted Ray. Now, did Mr. *Newton*'s doctrine hold, I conceiv'd, I ſhould not ſee all the mentioned Colours in a ſtreight line with the Ruler, in regard the unequal refrangibility of different Rays muſt needs diſplace ſome more than others. Yet in effect,upon many Trials, I conſtantly found them in as ſtreight a line as the bare Ruler had appeared in.

3. To advance this Experiment, I adjoyned a ſecond refraction to the former of the Water, by placing my Priſm ſo as to receive *perpendicularly* the refracted *ſpecies* of the Silk and Ruler; whereby only the emergent *ſpecies* ſuffered a ſecond refraction. But ſtill with equal ſucceſs, as to their appearing in a ſtraight line, to the eye placed behind the Priſm.

4. To theſe two Refractions I further added a third, by receiving the coloured ſpecies *obliquely* upon the Priſm; whereby both incident and emergent *ſpecies* ſuffered their reſpective refractions. But ſtill with the ſame ſucceſs as formerly, as to the ſtreight line they appeared in.

For

For further aſſurance in this Experiment, leſt prepoſſeſſion, occaſioned from previous knowledge of the Silks ſcituation in a ſtreight line, might poſſibly prejudice the judgment of the eye (as ſometimes I have obſerved to happen to the judgment the Eye paſſeth upon the diſtance of Objects) I called into the room ſome unconcerned perſons, wholly ignorant what the Experiment aimed at; and demanding whether they ſaw not the coloured Silks and Ruler in a crooked line? they anſwered in the negative.

5. The next Experiment I made in uncompounded Colours (as Mr. *Newton* terms them, *Prop.* 5 & 13.) as follows. Having caſt two coloured Images upon the Wall, ſo as the Scarlet colour of the one did fall in a ſtreight line (parallel to the Horizon) with the Violet of the other: I then looked upon both through another Priſm, and found them ſtill appear in a ſtreight line parallel to the Horizon, as they had formerly done to the naked eye. Now according to Mr. *Newton's* Aſſertion of different refrangibility in different Rays, I conceive the Violet rays ſhould ſuffer a greater refraction in the Priſm at the eye, than the Scarlet ones, and conſequently both colours ſhould not appear in a ſtreight line parallel to the Horizon.

6. Another Experiment I made in order to ſome further diſcovery of that ſurprizing *Phænomenon* of the coloured Image, which occaſioned Mr. *Newtons* ingenious Theory of *Light* and *Colours*, as alſo his excellent invention of the reflecting *Teleſcope* and *Microſcope.* Having then ſometimes ſuſpected, that not only the direct Sun-beams, but alſo other extraneous light might poſſibly influence the coloured *Spectrum*, I hoped to diſcover the truth of this ſuſpicion by means of the Sun-ſpots, made to appear in the coloured Image by placing a Teleſcope behind the Priſm. But my endeavours proving ineffectual herein by reaſon of ſome intervening difficulties, I thought at length of a more feaſible method in order to the deſigned diſcovery, as in the following Experiment.

I faſtened a very white Paper-circle (about an inch in diameter) upon my Window-ſhuts; and beholding it through my Priſm, I found a Coloured image painted thereby upon my *Retina*, anſwerable in almoſt all reſpects to the former of the

Sun

Sun-beams upon the Wall, eſpecially when the Paper-circle was indifferently well illuminated. This Image indeed appeared contrary to the former as to the ſcituation of Colours, that is, the Scarlet appearing above, the Violet below, though but faint. But this I was not ſurprized at, having obſerv'd upon diſſecting the eye, that objects are painted on the *Retina* after a contrary poſture to what they appear to Sight. Having thus rendred the Coloured image much more tractable than formerly it was, I conceived good hopes of ſome further diſcovery in the point mentioned.

V. Tab.II. Fig. 5 & 6.

In purſuance then of my former ſuſpicion, having fixed my Priſm in a ſteady poſture, I cauſed the paper *C* to be applied cloſe up to the Paper-circle *a b d*: whereupon the former Violet *d*, and Scarlet colour of *C* vaniſhed into whiteneſs. Next, I removed the mentioned Circle from the Shuts, and placed it in the open window, ſupported only by the edge *d*: whereupon, to my aſtoniſhment, all the former Colours exchanged poſtures in the *Retina*, the Scarlet now appearing below, the Violet above; the intermediate Colours ſcarce diſcernible. And here, on the by, 'tis very remarkable, that, during this Obſervation, I clearly perceived both Blew- and Scarlet-light to be tranſparent, I being able to diſcern ſeveral objects through both, namely Steeples oppoſit to my window. Whence it follows, that theſe Colours do in great part ariſe from the neighbouring light. Laſtly, I placed the Paper-circle anew, ſo as the one half *b* was faſtened to the Shuts, the other ſemicircle *a* being expoſed to the open Air. Whereupon the ſemicircle *a* became bordered with Violet above, Scarlet below; but the other ſemicircle *b* quite contrary. Hence I make the following Inferences.

Firſt, That not only the Light reflected from the Paper-circle, but alſo from the ambient Air, hath great influence upon the Coloured image, eſpecially as to the Violet and Scarlet colours. Whence perchance it will not hereafter ſeem ſtrange, that the coloured *Spectrum* on the Wall is ſo long, but only that the breadth is not greater. *Secondly*, Were there a more luminous body behind the Sun, we ſhould in all likelyhood have the colours of the *Spectrum* in a contrary ſcituation to what they appear in at preſent: Whence (*thirdly*) it ſeems to follow, that the preſent ſcituation and order of Colours, ariſeth not from any intrinſecal property of refrangibility (as maintained by Mr. *Newton*) but from contingent and extrinſecal circumſtances of neighbouring objects. For accordingly as the body behind the Paper-circle was more or leſs illuminated than the Circle it ſelf, all the ſeveral Colours changed their ſcituation.

8. The next Experiment was made in order to Mr. *Newtons* doctrine of primary Colours, as *Prop.*5. Having covered the Hole in the Window-ſhuts with a thin ſlice of *Ivory*, the tranſmitted light appeared yellow; but upon adding three, four, and more ſlices, it became red. Whence it ſeems to follow, that Yellowneſs of light is not a primary colour, but a compound of Red, &c.

9. The laſt Experiment was made in reference to Mr. *Newton*'s 12 *Prop.* where from his own principles he renders a very plauſible Reaſon of a ſurprizing *Phænomenon*, related by Mr. *Hooke*; namely of two liquors, the one Blew, the other Red, both ſeverally tranſparent, yet both, if placed together, became opake. The reaſon whereof, ſaith Mr. *Newton*, is, becauſe if one liquor tranſmitted only Red, the other only Blew, no rays could paſs through both.

In reference then to this point, I filled two ſmall Glaſſes with flat poliſhed bottoms, the one with *Aqua fortis*, deeply died Blew; the other with Oyl of *Turpentine*, died Red; both to that degree, as to repreſent all objects through them reſpectively Blew or Red. Then placing the one upon the other, I was able to diſcern ſeveral bodies through both: whereas according to Mr. *Newtons* Theory, no object ſhould appear through both Liquors; becauſe if one tranſmit only Red, the other only Blew, no rays can paſs through both.

Theſe Experimental Exceptions will not, I hope, be unwelcome to Mr. *Newton*, his only aim being the improvement of Natural knowledge, as it is alſo of,

Sir,
Your humble Servant,
Anthony Lucas.

Poſtſcript.

Juſt upon the cloſe of the adjoyned Letter, I received from Mr. Gaſcoine, *yours of* May *the fourth; wherein you are pleaſed to favour us with an exact account of the famous Experiment of the coloured* Spectrum, *lately exhibited before the* Royal Society. *I was much rejoyced to ſee the Trials of that Illuſtrious Company, agree ſo exactly with ours here, though in ſomewhat ours diſagree from Mr.* Newton, *as you will underſtand by the incloſed impartial account from,*

Sir, &c.

Mr. Newton'*s Anſwer to the precedent Letter, ſent to the Publiſher.*

Sir,

THe things oppoſed by Mr. *Line* being upon Trials found true and granted me; I begin with the new queſtion about the proportion of the length of the Image to its breadth. This I call a *new one*; for, though Mr. *Line* in his laſt Letter ſpake againſt ſo great a length as I aſſign, yet, as it ſeems to me, it was not to grant any tranſverſe length ſhorter than that aſſigned by me, (for in his firſt Letter he abſolutely denied that there would be any ſuch length;) but to lay the greater emphaſis upon his diſcourſe whilſt in defence of common Optiques he was diſputing in general againſt a tranſverſe Image: And therefore in my Anſwer I did not preſcribe the juſt quantity of the refracting Angle with which I would have the Experiment repeated: which would have been a neceſſary circumſtance, had the diſpute been about the juſt proportion of the length to the breadth. Yet I added,* this Note, that the bigger the angle of the Priſm is, the greater will be the length in proportion to the breadth; not imagining but that when he had found in any Priſm the length of the Image tranſverſe to the axis he would eaſily thence conclude, that a Priſm with a greater angle would make the Image longer, and conſequently that by uſing an angle great enough he might bring it to equal or exceed the length aſſigned by me; as indeed he might: for by taking an Angle of 70 or 75 degrees, or a little greater.

* *In my firſt Letter in* Phil. Tranſ. N. 123. p. 5099. l. 10.

Tab. II.

Ph Tr N° . 128.

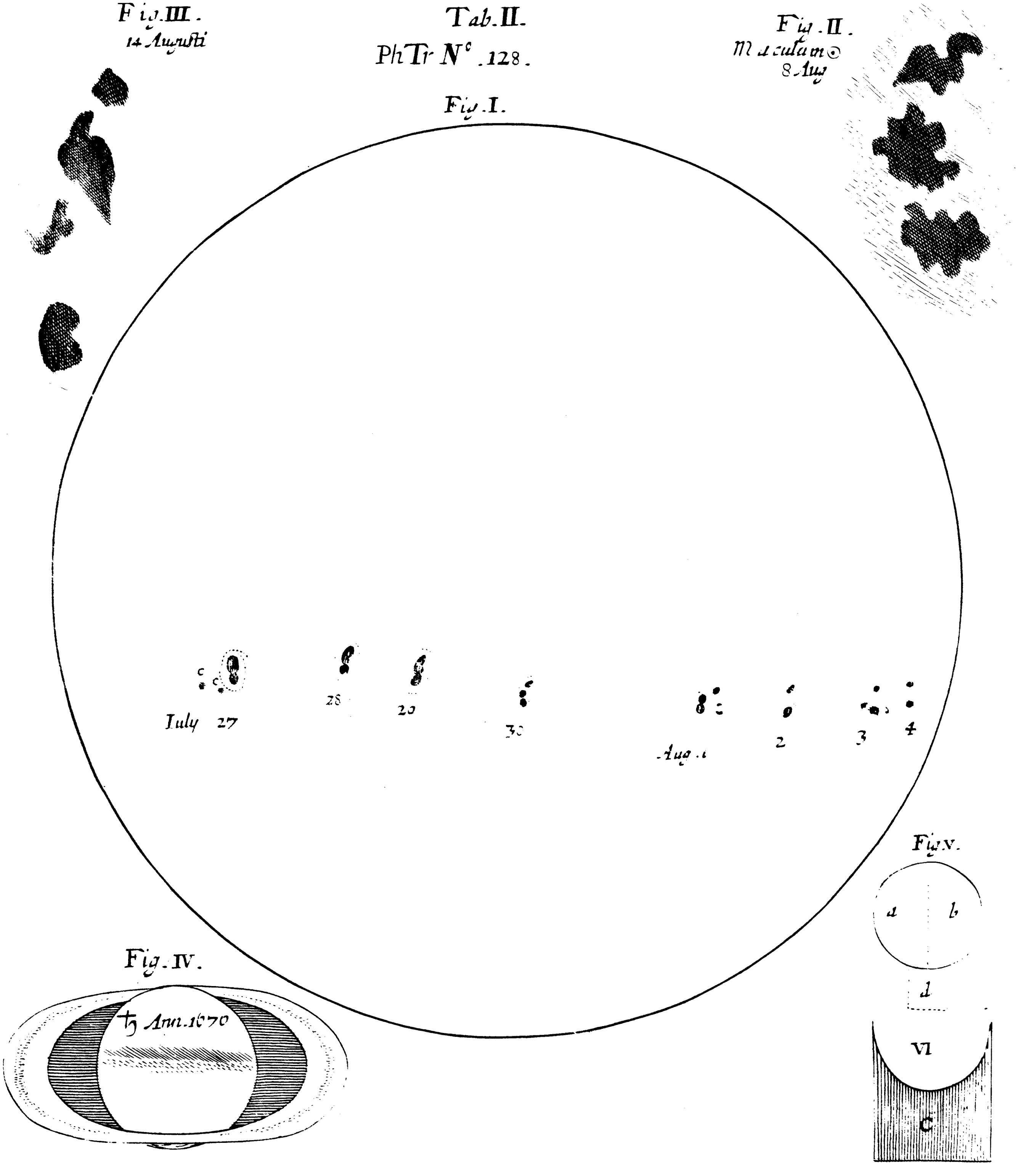

Fig. I.

Fig. II. Macula in ☉ 8 Aug

Fig. III. 14 Augusti

Fig. IV.

Fig. V.